(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 765 828 B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
26.04.2023 Bulletin 2023/17

(21) Application number: **19714483.5**

(22) Date of filing: **14.03.2019**

(51) International Patent Classification (IPC):
G01L 1/14 *(2006.01)* ***G01L 5/20*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
G01L 1/142; G01L 5/20

(86) International application number:
PCT/IB2019/052091

(87) International publication number:
WO 2019/175833 (19.09.2019 Gazette 2019/38)

(54) **RIM WITH SENSOR AND WHEEL INCLUDING THAT RIM**

FELGE FÜR RAD MIT SENSOR UND RAD MIT DIESER FELGE

JANTE DE ROUE COMPRENANT UN CAPTEUR ET ROUE COMPRENANT LADITE JANTE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **16.03.2018 IT 201800003697**

(43) Date of publication of application:
20.01.2021 Bulletin 2021/03

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Description

TECHNICAL FIELD

[0001] The present invention relates to the sector of control systems for motor vehicles and in particular to that of sensored wheels.

BACKGROUND

[0002] There is currently a strongly felt need to monitor the operating conditions of road vehicles, both for the purpose of guaranteeing road safety, and for planning road maintenance. For example, knowing the weight of the vehicles that transit on a road allows the wear on the road surface to be estimated and the resurfacing thereof to be suitably planned.

[0003] In order to monitor the operating conditions of a vehicle, and in particular the load on a wheel, many solutions have been proposed.

[0004] Patents US20070065060 and EP0637734 envisage the use of a load sensor inside the ball bearing that uncouples the axle shaft from the hub bracket. The sensor is, however, located in a position that is difficult to reach in the event of maintenance.

[0005] Patents US2009180722 and US5793285 disclose the use of sensors for measuring hub deformations. However, also in this case, access to the sensor for maintenance is complicated.

[0006] Other systems, such as EP1516794 and DE19744611, instead envisage sensors that are mounted on the wheel. In particular, these solutions exploit optical systems that are placed between the rim and the tyre that determine the load as a function of the deflection of the tyre. However, these systems have the limit that the deformation of the tyre depends not only on the load applied, but also on the mix and structure of the tyre, thus with the same load applied different tyres are deformed in different ways.

[0007] EP1426259 describes a method and a device for determining the force exerted on a wheel of a vehicle. In the first place, data are obtained on a relationship between the tension of the wheel in angularly and radially predetermined measurement positions. The data obtained are used to define a formula of the force acting on the wheel. During the rolling of the wheel the physical parameter is measured and the force is processed.

[0008] DE10001272 describes a wheel of a vehicle in which a sensor is arranged on the perimeter of the wheel rim, to measure the deformation of the rim in the peripheral direction. Furthermore, a processing unit determines predetermined forces of a tyre through a calculation process based on the deformations detected on the perimeter of the rim. US9404820 describes a method for measuring the forces and moments generated by the tyre-road contact from the combination of deformation signals measured in different angular and radial positions of the wheel. The combination of deformation signals implies six or more independent signals from the angular position of the measurement sensors with respect to the tyre-road contact point. Said signals provide estimates of the loads through the resolution of two systems of linear equations with constant matrices and three unknowns each.

[0009] WO2005108945 describes a method for determining the force at the hub of a wheel of a vehicle whilst travelling. The wheel comprises a rim and at least one deformation sensor directly associated with said rim in at least one predetermined position and arranged according to at least one predetermined orientation. The method envisages detecting at least one deformation component of said rim during rotation. Then a correlation parameter is applied to the deformation component between the force at the hub and the relative deformation of said rim, which is characteristic of the rim used, to determine at least one force component at the hub.

[0010] WO2018016236 describes a wheel provided with a detection device. The detection device comprises a shift extraction element, a part to be detected and a detecting part. The shift extraction element extends in the radial direction of the wheel, and comprises a free end and a constrained end. The detecting part is coupled to the free end of the shift extraction element in proximity to the part to be detected. The output signal of the detection device changes based on changes in the positional relationship of the detecting part and of the part to be detected.

[0011] Therefore, a need is perceived for monitoring systems that allow efficient measurement of the load supported by a wheel and are at the same time easy to install and maintain.

OBJECTS AND SUMMARY OF THE INVENTION

[0012] It is therefore an object of the present invention to solve the problems of known systems for monitoring the load applied to a wheel of a vehicle.

[0013] In particular, it is an object of the present invention to allow easy installation of the system for measuring the load applied to the wheel of a vehicle.

[0014] It is also an object of the present invention to allow easier maintenance of the system for measuring the load applied to the wheel of a vehicle.

[0015] These and other objects of the present invention will become clearer from the following description and appended claims, which form an integral part of the present description.

[0016] According to a first aspect, the invention therefore relates to a rim for wheel comprising a measuring system for detecting a vertical load applied to the wheel in mounted wheel conditions with a horizontal rotation axis. The measuring system comprises a sensor that detects a deformation of the rim and transmits a relevant deformation signal to a processing unit. The latter receives the deformation signal and determines the vertical load applied to the wheel.

[0017] This solution offers the advantage of allowing quick installation of the measuring system on the vehicle. In fact, it is sufficient to change the wheel of a vehicle without a measuring system to equip the vehicle with a measuring system.

[0018] In one embodiment, the sensor is housed in a seat on a surface of the rim and the sensor is adapted to detect a deformation of such seat. In particular, if the rim comprises a plurality of spokes then the seat is preferably obtained on one of these spokes. If the rim is of the type that comprises an annular element adapted to house a tyre, and a frontal disc applied to the aforementioned annular element, then the seat is preferably obtained on a surface of the disc that faces the annular element.

[0019] Reading the deformation of a seat obtained on the rim is particularly advantageous as it has contained dimensions and is therefore suited to allowing a detection of the load with greater precision. Then, placing the seat in points that are particularly strained by the vertical load, such as those indicated above, allows the deformations of the seat to be appreciated more and the measurement of the load to be improved.

[0020] Preferably the sensor is a capacitive type sensor comprising a pair of metal plates and a dielectric material interposed between said metalThis solution is particularly advantageous as the deformation of the rim and, in particular, of the seat that houses the sensor, cause a relative movement of the plates depending on the load.

[0021] Then, advantageously, in the case of a capacitive type sensor, this dielectric material is chosen in the group comprising the following materials: cellulose acetate, copolymers, fluoropolymers, Polymers, Tedlar ®. These materials are particularly efficient in the working range envisaged for most ground vehicles such as cars that travel at any average speed comprised between 0 and 130 km/h.

[0022] In one embodiment, the processing unit is adapted to store measurements made by the sensor and to detect a first absolute minimum value L_{MIN} of the deformation signal, a second absolute maximum value L_{MAX} of the deformation signal and a relative minimum value L_{t_med} of the deformation signal. The processing unit is therefore configured to calculate a value of the vertical load applied to the wheel according to the following formula:

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix}$$

where Fv is said vertical load, F_L is a lateral load applied to the wheel, the coefficients C_{ij} , with i ranging between 1 and 2 and j between 1 and 3, are constant.

[0023] In one embodiment, the measuring signal also comprises means for detecting a pressure of a tyre mounted on the rim, and the processing unit is configured to correct the value of the Cij coefficients as follows:

$$Cij' = Cij * k * P$$

where P is the measured pressure value and k a predetermined constant.

[0024] In one embodiment, the rim further comprises means adapted to detect a temperature value of the tyre. In this embodiment, the processing unit is adapted to store measurements made by said sensor and to detect a first absolute minimum value L_{MIN} of the deformation signal, a second absolute maximum value L_{MAX} of the deformation signal and a relative minimum value L_{t_med} of the deformation signal. The processing unit is therefore adapted to calculate a value of the vertical load applied to the wheel according to the following formula:

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix} + \begin{bmatrix} K_1 \\ K_2 \end{bmatrix}$$

where Fv is said vertical load, F_L is a lateral load applied to the wheel, the coefficients C_{ij} , with i ranging between 1 and 2 and j between 1 and 3, are constant, and wherein K_1 and K_2 depend on the temperature measured.

[0025] In this embodiment, the measuring system comprises means adapted to detect a temperature value of the tyre and the processing unit is configured to determine K_1 and K_2 , for example through selection from among a plurality of stored values, as a function of the detected temperature value.

[0026] The invention also relates to a wheel comprising a tyre mounted on a rim provided with a measuring system as indicated above and better described in the following preferred embodiments.

[0027] The invention also relates to a vehicle, e.g. a car or a truck, comprising the aforesaid wheel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Further features and advantages of the present invention will be more evident from the following description of some preferred embodiments thereof made with reference to the appended drawings.

[0029] The different features in the individual configurations can be combined with each other as preferred according to the previous description, should it be necessary to avail of the advantages resulting specifically from a particular combination.

[0030] In such drawings,

- Figure 1 illustrates a wheel according to an embodiment of the present invention;
- Figure 2A illustrates a sensor inserted in a seat provided in the rim of the wheel of Figure 1;
- Figure 2B schematically illustrates a deformation of the rim and of the sensor of Figure 2A when the wheel is subject to a vertical load;
- Figure 3 illustrates the attenuation of the output signal of the sensor used in the wheel of Figure 1 as the frequency and the dielectric material used changes;
- Figure 4 illustrates the output of the sensor of Figure 1 as a function of the rotation angle of the wheel;
- Figure 5 illustrates the load variation measured by the sensor as a function of the rotation speed of the wheel;
- Figure 6 is a table that shows the influence of the longitudinal load on the measurement of the vertical one;
- Figure 7 illustrates the variation of the load measurement as the pressure increases;
- Figure 8 illustrates the measurement of the vertical load when a vertical and a horizontal load are applied;
- Figure 9 shows an alternative rim to that of figure 1;
- Figures 10A, 10B, 10C, 10D, 10E show different alternative embodiments for the plates of a capacitive sensor.

DETAILED DESCRIPTION OF THE INVENTION

[0031] In the following description, for the illustration of the figures, identical numbers or reference symbols are used to indicate construction elements with the same function. Further, for illustration clarity, some references may not be repeated in all the figures.

[0032] While the invention is susceptible to various modifications and alternative constructions, certain preferred embodiments are shown in the drawings and are described hereinbelow in detail. It is in any case to be noted that there is no intention to limit the invention to the specific embodiment illustrated, rather on the contrary, the invention intends covering all the modifications, alternative and equivalent constructions that fall within the scope of the invention as defined in the claims.

[0033] The use of "for example", "etc.", "or" indicates non-exclusive alternatives without limitation, unless otherwise indicated. The use of "comprises" and "includes" means "comprises or includes, but not limited to", unless otherwise indicated.

[0034] With reference to Figure 1 a sectional view of a wheel 1 is illustrated according to an embodiment of the present invention. In the following description the wheel is considered in the mounted condition, i.e. with a horizontal rotation axis.

[0035] The wheel 1 comprises in a known way a rim 2 on which a tyre 3 is mounted, and a measuring system able to measure a vertical load applied to the wheel in mounted conditions with a horizontal rotation axis.

[0036] In the example of Figure 1 the rim is of the type comprising a frontal disc 20 welded to an annular element 21 whose radial surface forms the so-called channel 22 intended to house the heel 30 of the tyre 3.

[0037] The rim 1 is provided with a seat 23 in which a sensor 4 is housed that can detect deformations of the seat 23. Preferably the sensor 4 is a capacitive sensor, therefore provided with two conducting plates 40 separated by a dielectric material 41.

[0038] The dielectric material 41 can be of various types, however, preferred materials are cellulose acetate, copolymers, fluoropolymers, thermopolymers and Tedlar®. Experimental tests performed by the Applicant (see Fig. 3), have demonstrated that these materials have reduced signal attenuation (percentage less than 10%) for the frequencies of interest, comprised between 0 and 50 Hz, corresponding to the rotation frequency of the sensor mounted on a rim of

22" of a vehicle that travels at a speed comprised between 0 and 130 km/h.

[0039] As illustrated in Figure 2A, in conditions of null load applied to the wheel, the two elements 21 and 22 which, facing each other, define the walls of the seat 23 of the sensor are not deformed and the output of the electric signal of the sensor is stable at a threshold value that indicates a null load condition. When, instead, the wheel is subjected to a load (fig.2B), the two elements 21 and 22 are deformed and with them the shape of the seat 23, so that the two plates 40 of the sensor 4 move translating and rotating with respect to each other. Such movement of the plates causes a deformation of the dielectric material 41 and, therefore, a variation of the electric signal generated by the sensor. The variation of the electric signal of the sensor therefore depends on the load applied to the wheel and its measurement can be used to measure the load on the wheel.

[0040] Advantageously, the plates of the capacitive sensor are shielded by means of a conductive layer, so as to reduce the noise coming from the vehicle, e.g. due to capacity due to contact between wheel and vehicle/ground.

[0041] In the example of Figure 1, the capacitive sensor 4 is mounted on a PCB that also houses an analog-to-digital converter 5. The output of the sensor 4 is connected to the input of the analog-to-digital converter (A/D) 5, which converts the analog signal at the output of the sensor 4 into a digital signal that is then sent, through appropriate wiring 10, to a storage and processing unit 6, which performs a first local processing of the measurement of the sensor 4 and supplies the data to a wireless transmitter module 7 which transmits them to a remote unit, not illustrated in the figure, but preferably mounted on board the vehicle, e.g. a car or truck, on which the wheel 1 is mounted.

[0042] In the example of Figure 1, the wireless transmitter 7 and the storage and processing unit 6 are housed in a case 8 that also houses an electric battery 9 able to supply the transmitter and all the other active elements of the system, such as the sensor 4, the A/D converter 5.

[0043] Experimental tests, reported in Figure 4, have made it possible to verify that by applying a constant vertical load to the wheel, as the latter rotates, the output signal of the sensor has a peak L_{MAX}, when the sensor is located along the horizontal (values of 90° and 270° in the graphs of Figure 4). The output signal of the sensor, instead, has an absolute minimum value L_{MIN} when it is in the lowest part of the wheel (values of 0 and 360° in the graph of figure 4), and a relative minimum L_{t_med} when it is in the highest point of the wheel (value of 180° in the graph of Figure 4).

[0044] Preferably, the absolute maximum L_{MAX}, absolute minimum L_{MIN} and relative minimum L_{t_med} values are considered net of the disturbances and noise associated with the output signal of the sensor 4, as appears clear to a person skilled in the art from the example of Figure 4. For example, the absolute maximum and minimum and relative values can be detected after filtering - such as lowpass filtering or bandpass filtering - of the output signal of the sensor 4, performed by the processing unit 6.

[0045] The Applicant has therefore, empirically, discovered that the lateral F_L and vertical Fv forces acting on the wheel can be obtained according to the following formula (1):

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix} + \begin{bmatrix} K_1 \\ K_2 \end{bmatrix} \qquad (1)$$

wherein the coefficients Cij are constant and depend on the pressure of the tyre.

[0046] In order to be able to calculate the vertical load Fv and lateral load F_L values, in a preferred embodiment the system for measuring the loads applied to the wheel also comprises means adapted to detect a pressure and temperature value of the tyre mounted on the rim. In one embodiment the means adapted to detect a pressure and temperature value comprise a sensor, e.g. a TPMS sensor, able to measure the inflation pressure of the tyre and the temperature of the air inside the tyre, the latter being connected to the temperature of the tyre itself.

[0047] In particular, it is to be noted that although the use of a pressure sensor is preferable for measuring the pressure of the tyre, other systems may be used, which indirectly determine a pressure value by measuring other parameters. For example, the measurement of the distance between the rim and the tyre depends on the shape, but also on the pressure, of the tyre, so that differential measurements of the distance between the rim and the tyre can be considered indirect measurements of the tyre pressure.

[0048] The means for detecting a pressure and temperature value of the tyre mounted on the rim can be mounted on the wheel, or be means already provided on the vehicle that mounts the wheel. In this case the storage and processing unit 6 can receive the pressure and temperature data from the remote unit of the vehicle through the wireless interface 7 that operates both as a transmitting module, as previously described, and as a receiving module for receiving data and/or controls from the remote unit of the vehicle.

[0049] In general, the coefficient values Cij can be empirically measured. The Applicant has verified that in tyre pressure conditions of 4 bar and temperature of 20°C the following values are recorded:

$$C_{11}= -1.12\cdot 10^{-1}; C_{12}=-1.58\cdot 10^{-2} ; C_{13}= 1.28\cdot 10^{-1};$$

$$C_{21}=-5.33\cdot 10^{-2} ; C_{22}=-3.57\cdot 10^{-2} ; C_{23}=8.9 \cdot 10^{-2} ;$$

[0050] In general, in usual operating conditions of a wheel, i.e. T comprised between - 15°C and T=45°C, and tyre pressure p comprised between 3 and 4.5 bar (commercial vehicle), the values mentioned above can vary by ± 10%.

[0051] Although slightly less accurate, given that the temperature drift is not very important in formula (1), in an embodiment that does not require any temperature sensor, the values K_1 and K_2 can be assumed to be equal to zero in formula (1). Through experimental tests, the Applicant has also verified the existence of a linear relationship between the pressure of the tyre P and the coefficients Cij. The graph of Figure 7 shows how, with the same vertical load applied, as the pressure increases the load value measured by the sensor also increases.

[0052] Therefore, the processing unit 6 is preferably configured to correct the value of coefficients Cij of formula (1) as follows:

$$Cij' = Cij * k*P$$

where P is the pressure and k is the experimental correlation coefficient that determines the sensitivity of the sensor to the pressure. Preferred values of k are comprised between $1\cdot 10^4$ and $2\cdot 10^4$. In general, the value of k can however be defined during the manufacturing of the wheel and be stored in a storage area of the storage and processing unit 6. In one embodiment, the storage and processing unit 6 can comprise different values of k stored in a comparison table where, for different types of tyre and tyre pressure, a predetermined value of k is associated. At the time of mounting the wheel on the vehicle, the mechanic can interface with the storage and processing unit through an appropriate user interface (e.g. a remote control terminal that communicates in Bluetooth to the unit 6) for selecting the value of k.

[0053] Experimental tests, reported in Figure 8, have further demonstrated the effect of lateral forces on the measurement of the vertical force by the sensor that determine the ratio between the coefficients Cij.

[0054] Operatively, therefore, as the wheel 1 turns, the plates of the capacitive sensor 4 move with respect to each other deforming the dielectrics interposed between them. This implies a variation to the signal generated by the sensor which, under ideal conditions, is repeated cyclically at each rotation and that has an absolute maximum L_{MAX}, an absolute minimum L_{MIN} and a relative minimum L_{t_med}. The processing unit 6 detects and stores these three values and calculates the values the values of the horizontal forces F_L and vertical forces F_V acting on the wheel.

[0055] The processing unit 6 transmits at least the value of the vertical force F_V, but preferably also the value of the horizontal force F_O to the wireless transmitter 7.

[0056] The signal transmitted by the transmitter 7 is received by a remote control unit that re-transmits the signal (possibly re-processed) to external devices (e.g. remote control units) and/or uses the information transported by such signal (i.e. F_L and F_V) for controlling actuators of the vehicle, e.g. for switching on alarm signals in the case of sudden variations of the load measured by a wheel.

[0057] Experimental tests have made it possible to verify that the system described above is resistant to noise and other factors that can in some way affect the measurement.

[0058] In particular, as illustrated in Figure 5, the influence of the vehicle's translation speed is less than 4% and is random.

[0059] Experimental tests have then made it possible to verify (see table in Figure 6) that the influence of the longitudinal load on the measurement of the vertical one is less than 3%.

[0060] Furthermore, as will be clear to a person skilled in the art, the system according to the embodiments of the present invention requires a single deformation signal for precisely identifying the horizontal forces F_L and vertical forces F_V acting on the wheel. This allows a system to be realized with extremely reduced dimensions and a single cable - for connecting the single sensor 4 to the storage and processing unit 6.

[0061] In light of what is described above it is clear to a person skilled in the art how the invention allows the intended objects to be reached. In particular, the positioning of the sensor in a seat obtained in the rim of the wheel allows easy installation and facilitated access to the sensor in case of maintenance.

[0062] Advantageously, the seat for the sensor is positioned in a point of the rim that is subject to the vertical load acting on the wheel, e.g. a portion of the channel for housing the tyre, or a spoke of a spoked rim. Figure 9, for example, indicates different possible positions of a seat 23 for the sensor. Preferably, in case of spoked rims, a preferred position for the seat 23 is an area of the spoke that is located in the most external half of the spoke itself, i.e. in the proximal position of the channel.

[0063] For example, despite the invention being described above with reference to a capacitive type sensor, it is clear that the sensor can also be of another type, e.g. optical or inductive sensors can be provided, which measure deformations of a seat obtained in the rim.

[0064] Again, in the preferred solution of a capacitive condenser, it is clear that the sensor can have parallel plane plates or also of another type. For example, the plates can comprise parallel flat plane surfaces (e.g. Figures 10A and 10B) of any shape (e.g. rectangular as in Fig. 10A or elliptical as in Fig. 10B), or comprise curved plane surfaces (fig. 10C), comprise semi-circular surfaces (Fig. 10E), have a constant thickness along the whole width thereof (e.g. Fig. 10A-10C) have a thickness ’D’ that varies along the width, e.g. being maximum at the centre and minimum at the edges as in Fig. 10D.

Claims

1. Rim (2) for wheel (1) including a measuring system (4, 5, 6) to detect a vertical load (Fv) applied to the wheel (1) in operating conditions with wheel mounted with horizontal rotation axis, the measuring system comprising:

- a sensor (4) to detect a deformation of the rim and to transmit a deformation signal related to the detected deformation, and
- a processing unit (6), operatively connected to the sensor (4), configured to receive the deformation signal, and to determine the vertical load applied to the wheel (1), based on the deformation of the rim detected by the sensor (4), **characterized in that**

the processing unit:

detects and stores a first value (L_{MIN}) of absolute minimum, a second value (L_{MAX}) of absolute maximum and a value (Lt_med) of relative minimum of the deformation signal generated by said sensor (4) during a rotation of the rim (2), and

calculates the value of the vertical (F_V) load acting on the wheel, based on the first value (L_{MIN}) of absolute minimum, the second value (L_{MAX}) of absolute maximum and the value (Lt_med) of relative minimum of the deformation signal generated by said sensor (4) stored.

2. Rim according to claim 1, wherein the sensor (4) is housed in a seat (23) on a surface of the rim, said seat comprising two walls (21, 22) facing each other, and wherein the sensor is adapted to detect a deformation of said seat (23), said deformation of the seat (23) being caused by a deformation of the two walls due to a load applied to wheel (1) coupled with the rim (2).

3. Rim according to claim 2, further comprising a plurality of spokes and wherein the seat (23) is obtained on a spoke of the said plurality of spokes.

4. Rim according to claim 2, further including an annular element to house a tyre, and a frontal disc applied to the annular element, and wherein the seat (23) is obtained on an area of the said disc that faces said annular element.

5. Rim according to claim 2 or 3 or 4, wherein the sensor (4) is a capacitive type sensor comprising a pair of conducting plates (40) and a dielectric material (41) interposed between said conducting plates.

6. Rim according to claim 5, wherein a first conducting plate (40) of the pair of conducting plates (40) is adjacent to a first wall (21) of the two walls (21, 22) of the seat (23) and a second conducting plate (40) is adjacent to a second wall (22) of the two walls (21,22) of the seat (23), the conducting plates (40) translating and rotating with respect to each other by a deformation of the two walls due to a load applied to wheel (1) coupled with the rim (2) causing a deformation of the dielectric material (41).

7. Rim According to claim 5 or 6, wherein this dielectric material is chosen in the group of materials comprising the following materials: cellulose acetate, copolymers, fluoropolymers, Polymers, Tedlar®.

8. Rim according to any of the previous claims, wherein the processing unit is further adapted to calculate a value of the vertical load applied to the wheel according to the following formula:

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix}$$

Where Fv is said vertical load, F_L is a lateral load applied to the wheel, the coefficients Cij, with i ranging between 1 and 2 and j between 1 and 3, are constant.

9. Rim according to any of claims 1 to 8, further comprising means adapted to detect a temperature value of the tyre and wherein said processing unit (6) is adapted to store measurements made by said sensor (4), and wherein the processing unit is further adapted to calculate a value of the vertical load applied to the wheel according to the following formula:

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix} + \begin{bmatrix} K_1 \\ K_2 \end{bmatrix}$$

Where Fv is said vertical load, F_L is a lateral load applied to the wheel, the coefficients Cij, with i ranging between 1 and 2 and j between 1 and 3, are constant, K_1 and K_2 are two values depending on said detected temperature value.

10. Rim according to claim 8 or 9, further comprising means for detecting pressure of a tyre mounted on said rim, and where the processing unit (6) is configured to correct the value of the Cij coefficients as follows:

$$Cij' = Cij * k * P$$

Where Cij' are the corrected Cij coefficients, P is the measured pressure value and k a predetermined constant.

11. Wheel comprising a rim according to any of the claims from 1 to 10 and a tyre mounted on that rim.

12. Vehicle comprising a wheel according to claim 11, wherein the measurement system comprises a wireless transmitter module (7) to transmit measurements of the load acting on the wheel, and wherein the vehicle comprises a remote unit adapted to receive said measurements of the load acting on the wheel.

13. Vehicle according to claim 12, further comprising a plurality of actuators, wherein the remote unit uses the measurements of the load acting on the wheel to control at least one actuator of said plurality of actuators.

Patentansprüche

1. Felge (2) für ein Rad (1), umfassend ein Messsystem (4, 5, 6) zum Erfassen einer vertikalen Last (F_V), die auf das Rad (1) unter Betriebsbedingungen, mit horizontaler Drehachse montiertem Rad, ausgeübt wird, wobei das Messsystem umfasst:

- einen Sensor (4) zum Erfassen einer Verformung der Felge und zum Übertragen eines auf die erfasste Verformung bezogenen Verformungssignals, und
- eine Verarbeitungseinheit (6), die operativ mit dem Sensor (4) verbunden ist und dazu eingerichtet ist, das Verformungssignal zu empfangen und die auf das Rad (1) ausgeübte vertikale Last auf der Grundlage der von dem Sensor (4) erfassten Verformung der Felge zu bestimmen,

dadurch gekennzeichnet, dass
die Verarbeitungseinheit:

einen ersten Wert (L_{MIN}) absoluten Minimums, einen zweiten Wert (L_{MAX}) absoluten Maximums und einen Wert (Lt_med) relativen Minimums des von dem Sensor (4) während einer Drehung der Felge (2) erzeugten Verformungssignals erfasst und speichert, und
den Wert der auf das Rad wirkenden vertikalen Last (F_V) auf der Grundlage des ersten Wertes (L_{MIN}) absoluten Minimums, des zweiten Wertes (L_{MAX}) absoluten Maximums und des Wertes (Lt_med) relativen Minimums des dem Sensor (4) erzeugten Verformungssignals, die gespeichert sind, berechnet.

2. Felge nach Anspruch 1, wobei der Sensor (4) in einem Sitz (23) auf einer Oberfläche der Felge untergebracht ist, wobei der Sitz zwei einander zugewandte Wände (21, 22) umfasst, und wobei der Sensor dazu eingerichtet ist, eine Verformung des Sitzes (23) zu erfassen, wobei diese Verformung des Sitzes (23) durch eine Verformung der beiden Wände aufgrund einer auf ein mit der Felge (2) verbundenes Rad (1) ausgeübten Last verursacht wird.

3. Felge nach Anspruch 2, die ferner eine Vielzahl von Speichen aufweist, wobei der Sitz (23) an einer Speiche der Vielzahl von Speichen ausgebildet ist.

4. Felge nach Anspruch 2, die ferner ein ringförmiges Element zur Aufnahme eines Reifens und eine an dem ringförmigen Element angebrachte Frontscheibe aufweist, wobei der Sitz (23) an einem Bereich der Frontscheibe ausgebildet ist, der dem ringförmigen Element zugewandt ist.

5. Felge nach Anspruch 2 oder 3 oder 4, wobei der Sensor (4) ein Sensor kapazitiven Typs ist, der ein Paar leitende Platten (40) und ein zwischen den leitenden Platten angeordnetes dielektrisches Material (41) umfasst.

6. Felge nach Anspruch 5, wobei eine erste leitende Platte (40) des Paares leitender Platten (40) an eine erste Wand (21) der beiden Wände (21, 22) des Sitzes (23) angrenzt und eine zweite leitende Platte (40) an eine zweite Wand (22) der beiden Wände (21, 22) des Sitzes (23) angrenzt, wobei sich die leitenden Platten (40) durch eine Verformung der beiden Wände aufgrund einer auf das mit der Felge (2) verbundene Rad (1) ausgeübten Last, gegeneinander verschieben und drehen, was eine Verformung des dielektrischen Materials (41) bewirkt.

7. Felge nach Anspruch 5 oder 6, wobei dieses dielektrische Material aus der Gruppe der Materialien ausgewählt ist, welche die folgenden Materialien umfasst: Celluloseacetat, Copolymere, Fluorpolymere, Polymere, Tedlar ®.

8. Felge nach einem der vorangehenden Ansprüche, wobei die Verarbeitungseinheit ferner dazu eingerichtet ist, einen Wert der auf das Rad ausgeübten vertikalen Last gemäß der folgenden Formel zu berechnen:

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix}$$

wobei Fv die vertikale Last ist, F_L eine auf das Rad ausgeübte seitliche Last ist, die Koeffizienten C_{ij}, wobei i von 1 bis 2 und j von 1 bis 3 reicht, konstant sind.

9. Felge nach einem der Ansprüche 1 bis 8, ferner umfassend Mittel, die dazu eingerichtet sind, einen Temperaturwert des Reifens zu erfassen, und wobei die Verarbeitungseinheit (6) dazu eingerichtet ist, von dem Sensor (4) vorgenommenen Messungen zu speichern, und wobei die Verarbeitungseinheit ferner dazu eingerichtet ist, einen Wert der auf das Rad ausgeübten vertikalen Last gemäß der folgenden Formel zu berechnen:

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix} + \begin{bmatrix} K_1 \\ K_2 \end{bmatrix}$$

wobei Fv die vertikale Last ist, F_L eine auf das Rad ausgeübte seitliche Last ist, die Koeffizienten C_{ij}, wobei i von 1 bis 2 und j von 1 bis 3 reicht, konstant sind, K_1 und K_2 zwei Werte sind, die von dem erfassten Temperaturwert abhängen.

10. Felge nach Anspruch 8 oder 9, ferner umfassend Mitteln zum Erfassen eines Drucks eines auf der Felge montierten Reifens, und wobei die Verarbeitungseinheit (6) dazu eingerichtet ist, den Wert der C_{ij} -Koeffizienten wie folgt zu korrigieren:

$$C_{ij}' = C_{ij} * k * P$$

wobei C_{ij}' die korrigierten C_{ij} -Koeffizienten sind, P der gemessene Druckwert und k eine vorbestimmte Konstante ist.

11. Rad mit einer Felge nach einem der Ansprüche 1 bis 10 und einem auf dieser Felge montierten Reifen.

12. Fahrzeug mit einem Rad nach Anspruch 11, wobei das Messsystem ein drahtloses Sendemodul (7) umfasst, um Messungen der auf das Rad wirkenden Last zu übertragen, und wobei das Fahrzeug eine Fernbedienungseinheit umfasst, die geeignet ist, die Messungen der auf das Rad wirkenden Last zu empfangen.

13. Fahrzeug nach Anspruch 12, das ferner eine Vielzahl von Stellgliedern umfasst, wobei die Fernbedienungseinheit die Messungen der auf das Rad wirkenden Last verwendet, um mindestens ein Stellglied der Vielzahl von Stellgliedern zu steuern.

Revendications

1. Jante (2) pour roue (1) comprenant un système de mesure (4, 5, 6) pour détecter une charge verticale (F_v) appliquée à la roue (1) dans des conditions de fonctionnement avec la roue montée avec un axe de rotation horizontal, le système de mesure comprenant :

- un capteur (4) pour détecter une déformation de la jante et pour émettre un signal de déformation lié à la déformation détectée, et
- une unité de traitement (6), reliée de manière fonctionnelle au capteur (4), configurée pour recevoir le signal de déformation et pour déterminer la charge verticale appliquée à la roue (1), sur la base de la déformation de la jante détectée par le capteur (4),

caractérisée par le fait que
l'unité de traitement (6) :

détecte et stocke une première valeur (L_{MIN}) de minimum absolu, une seconde valeur (L_{MAX}) de maximum absolu et une valeur (Lt_med) de minimum relatif du signal de déformation généré par ledit capteur (4) pendant une rotation de la jante (2), et
calcule la valeur de la charge verticale (F_v) agissant sur la roue, sur la base de la première valeur (L_{MIN}) de minimum absolu, de la seconde valeur (L_{MAX}) de maximum absolu et de la valeur (Lt_med) de minimum relatif du signal de déformation généré par ledit capteur (4) stocké.

2. Jante selon la revendication 1, dans laquelle le capteur (4) est reçu dans un siège (23) sur une surface de la jante, ledit siège comprenant deux parois (21, 22) se faisant mutuellement face, et dans laquelle le capteur est agencé pour détecter une déformation dudit siège (23), ladite déformation du siège (23) étant provoquée par une déformation des deux parois due à une charge appliquée à la roue (1) couplée à la jante (2).

3. Jante selon la revendication 2, comprenant en outre une pluralité de rayons et dans laquelle le siège (23) est obtenu sur un rayon de ladite pluralité de rayons.

4. Jante selon la revendication 2, comprenant en outre un élément annulaire pour recevoir un pneu, et un disque frontal appliqué à l'élément annulaire, et dans laquelle le siège (23) est obtenu sur une zone dudit disque qui fait face audit élément annulaire.

5. Jante selon la revendication 2 ou 3 ou 4, dans laquelle le capteur (4) est un capteur de type capacitif comprenant une paire de plaques conductrices (40) et un matériau diélectrique (41) interposé entre lesdites plaques conductrices.

6. Jante selon la revendication 5, dans laquelle une première plaque conductrice (40) de la paire de plaques conductrices (40) est adjacente à une première paroi (21) des deux parois (21, 22) du siège (23) et une seconde plaque conductrice (40) est adjacente à une seconde paroi (22) des deux parois (21, 22) du siège (23), les plaques conductrices (40) se déplaçant en translation et tournant l'une par rapport à l'autre par une déformation des deux parois due à une charge appliquée à la roue (1) couplée à la jante (2), provoquant une déformation du matériau diélectrique (41).

7. Jante selon la revendication 5 ou 6, dans laquelle ce matériau diélectrique est choisi parmi le groupe de matériaux comprenant les matériaux suivants : acétate de cellulose, copolymères, fluoropolymères, Polymères, Tedlar®.

8. Jante selon l'une quelconque des revendications précédentes, dans laquelle l'unité de traitement est en outre agencée pour calculer une valeur de la charge verticale appliquée à la roue selon la formule suivante :

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix}$$

où F_V est ladite charge verticale, F_L est une charge latérale appliquée à la roue, et les coefficients Cij, avec i compris entre 1 et 2 et j entre 1 et 3, sont constants.

9. Jante selon l'une quelconque des revendications 1 à 8, comprenant en outre des moyens agencés pour détecter une valeur de température du pneu, et dans laquelle ladite unité de traitement (6) est agencée pour stocker des mesures effectuées par ledit capteur (4), et dans laquelle l'unité de traitement est en outre agencée pour calculer une valeur de la charge verticale appliquée à la roue selon la formule suivante :

$$\begin{bmatrix} F_V \\ F_L \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} L_{MIN} \\ L_{MAX} \\ L_{t_{MED}} \end{bmatrix} + \begin{bmatrix} K_1 \\ K_2 \end{bmatrix}$$

où F_V est ladite charge verticale, F_L est une charge latérale appliquée à la roue, les coefficients Cij, avec i compris entre 1 et 2 et j entre 1 et 3, sont constants, et K_1 et K_2 sont deux valeurs dépendant de ladite valeur de température détectée.

10. Jante selon la revendication 8 ou 9, comprenant en outre des moyens de détection de pression d'un pneu monté sur ladite jante, et l'unité de traitement (6) étant configurée pour corriger la valeur des coefficients Cij de la manière suivante :

$$Cij' = Cij * k * P$$

où Cij' sont les coefficients Cij corrigés, P est la valeur de pression mesurée, et k une constante prédéterminée.

11. Roue comprenant une jante selon l'une quelconque des revendications de 1 à 10 et un pneu monté sur cette jante.

12. Véhicule comprenant une roue selon la revendication 11, dans lequel le système de mesure comprend un module émetteur sans fil (7) pour transmettre des mesures de la charge agissant sur la roue, et le véhicule comprenant une unité à distance agencée pour recevoir lesdites mesures de la charge agissant sur la roue.

13. Véhicule selon la revendication 12, comprenant en outre une pluralité d'actionneurs, dans lequel l'unité à distance utilise les mesures de la charge agissant sur la roue pour commander au moins un actionneur de ladite pluralité d'actionneurs.

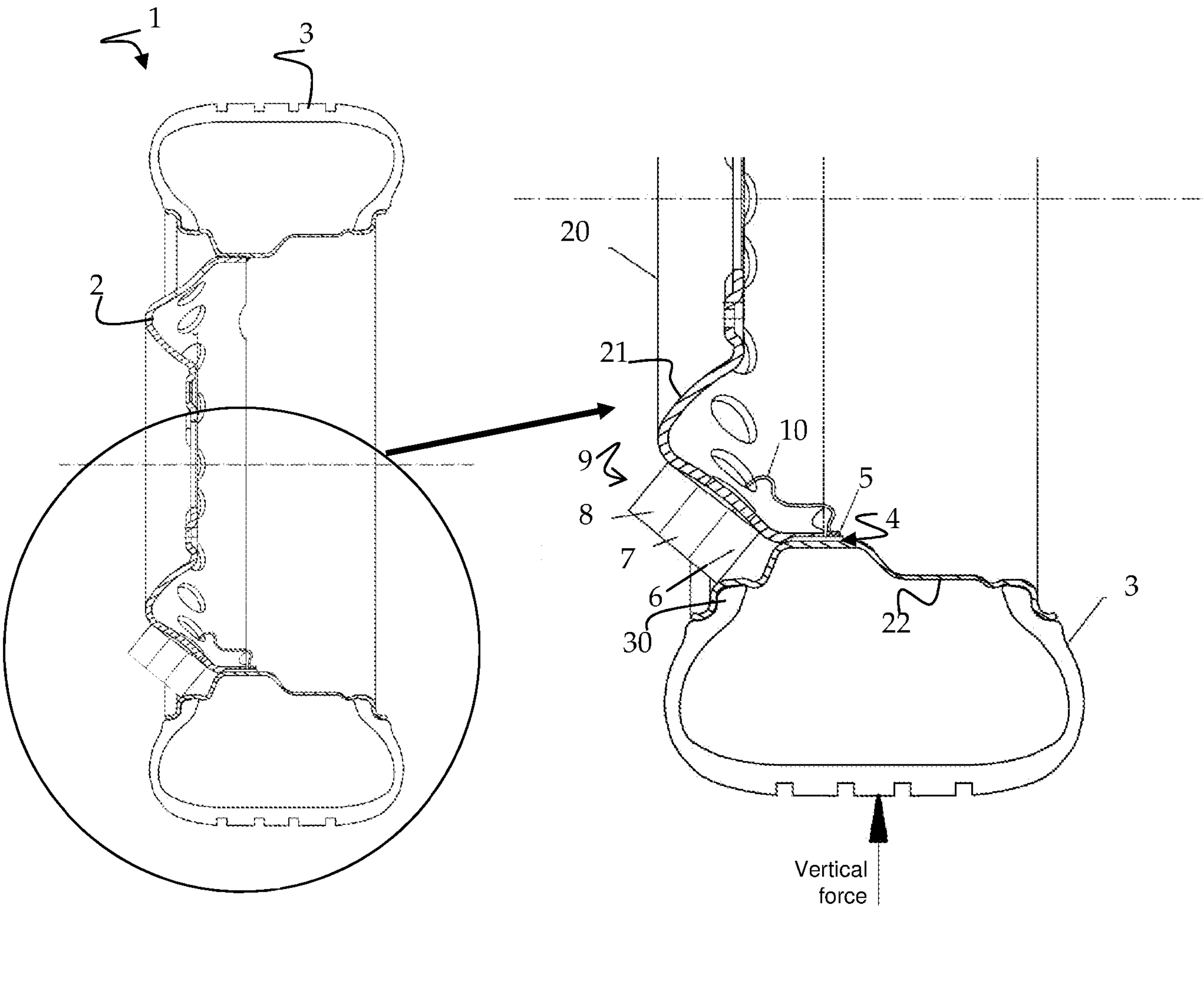

Fig. 1

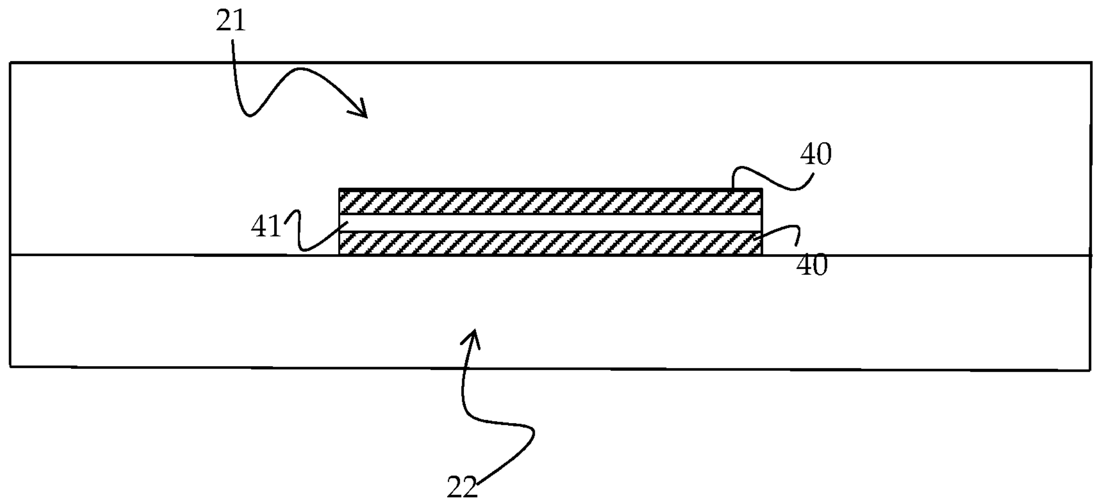

Fig. 2A

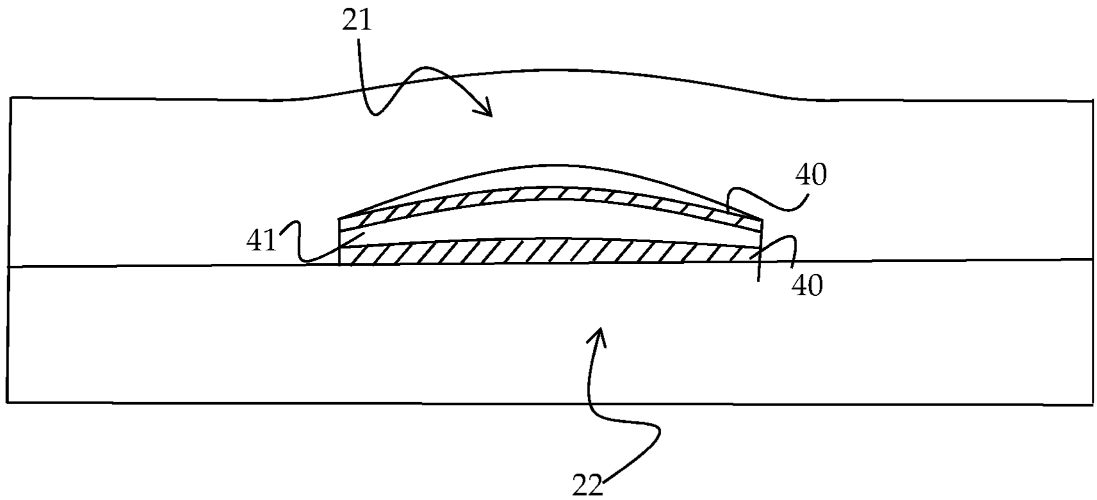

Fig. 2B

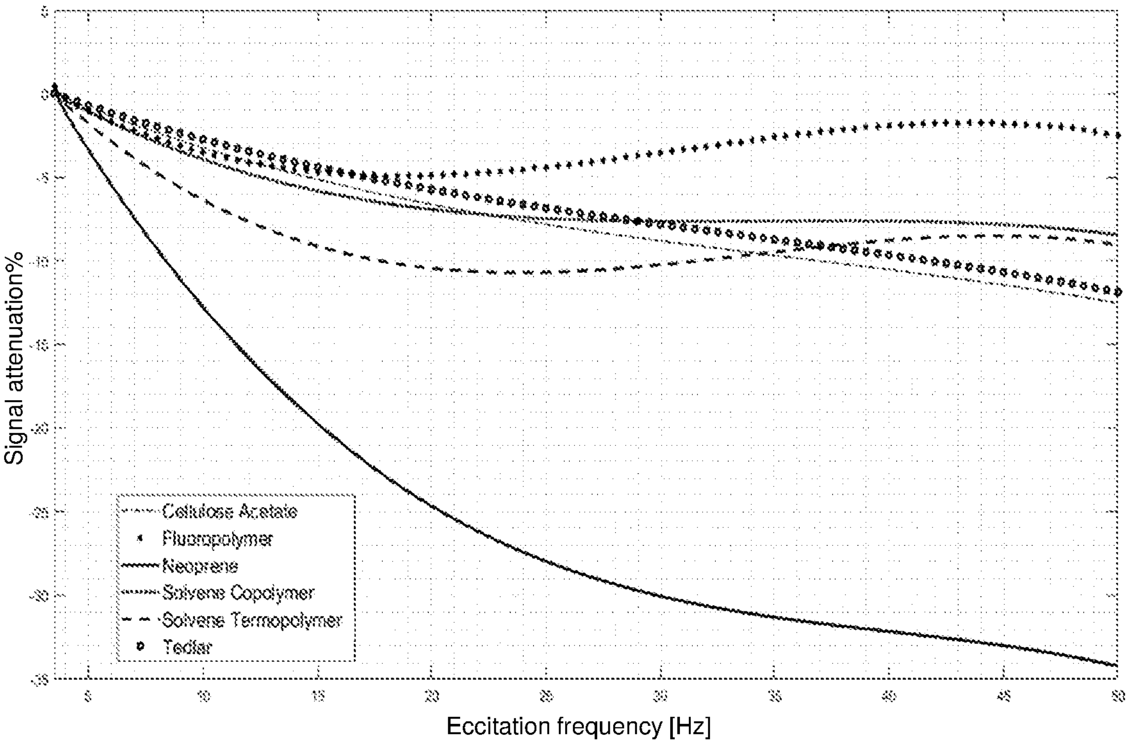
Signal attenuation%
Eccitation frequency [Hz]
Cellulose Acetate
Fluoropolymer
Neoprene
Solvene Copolymer
Solvene Termopolymer
Tedlar

Fig. 3

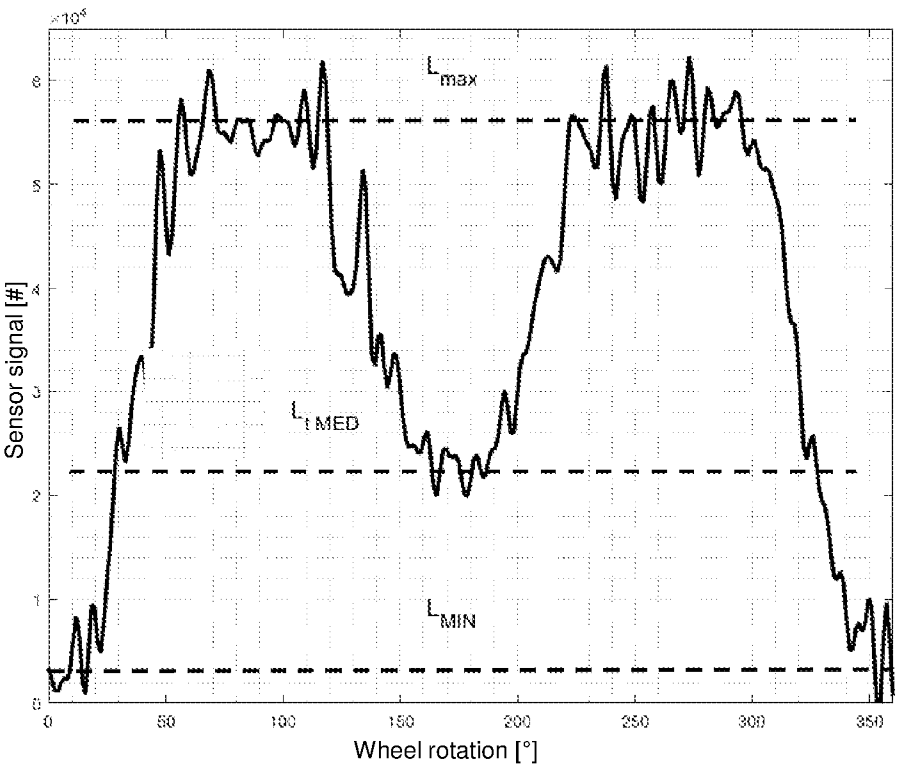
Sensor signal [#]
Wheel rotation [°]
L_{max}
$L_{t\ MED}$
L_{MIN}

Fig. 4

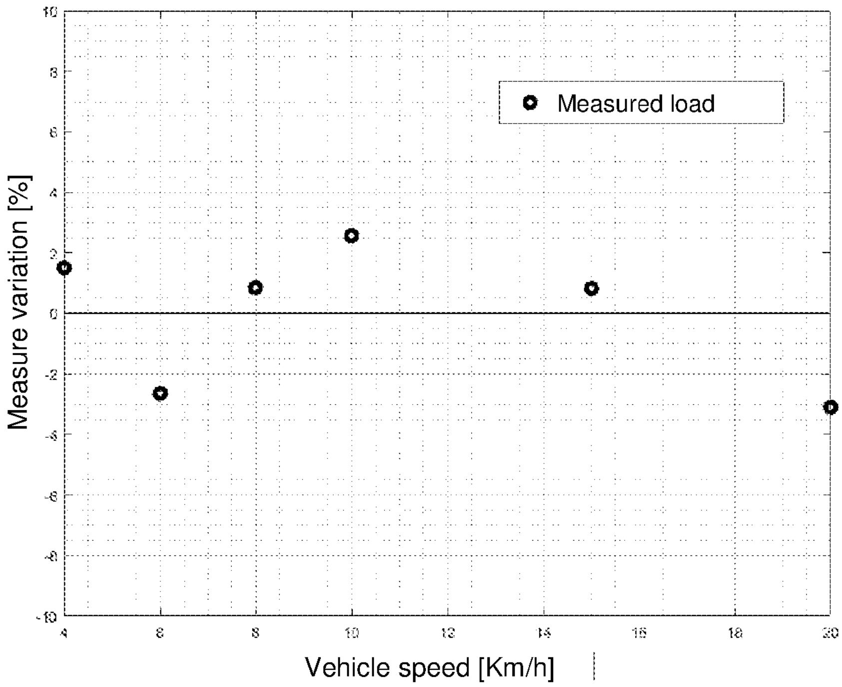

Fig. 5

Vertical force [N]	Longitudinal Force [N]	Longitudinal/Vertical ratio	ΔSignal [N]
4850	3650	0.75	50
7250	5500	0.75	100

Fig. 6

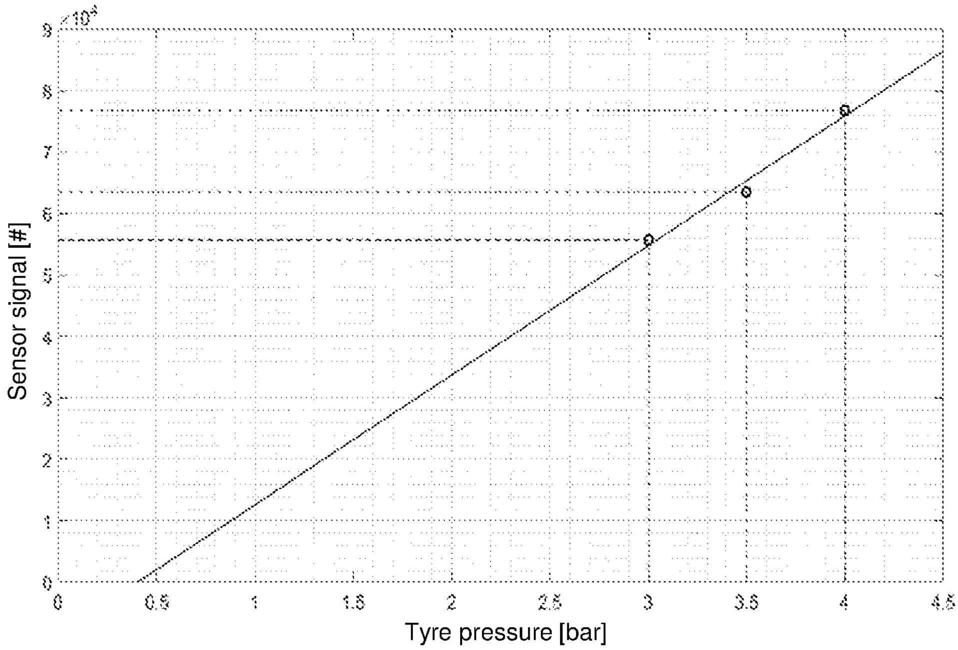
x10^4
Sensor signal [#]
Tyre pressure [bar]
0
1
2
3
4
5
6
7
8
9
0.5
1.5
2.5
3.5
4.5

Fig. 7

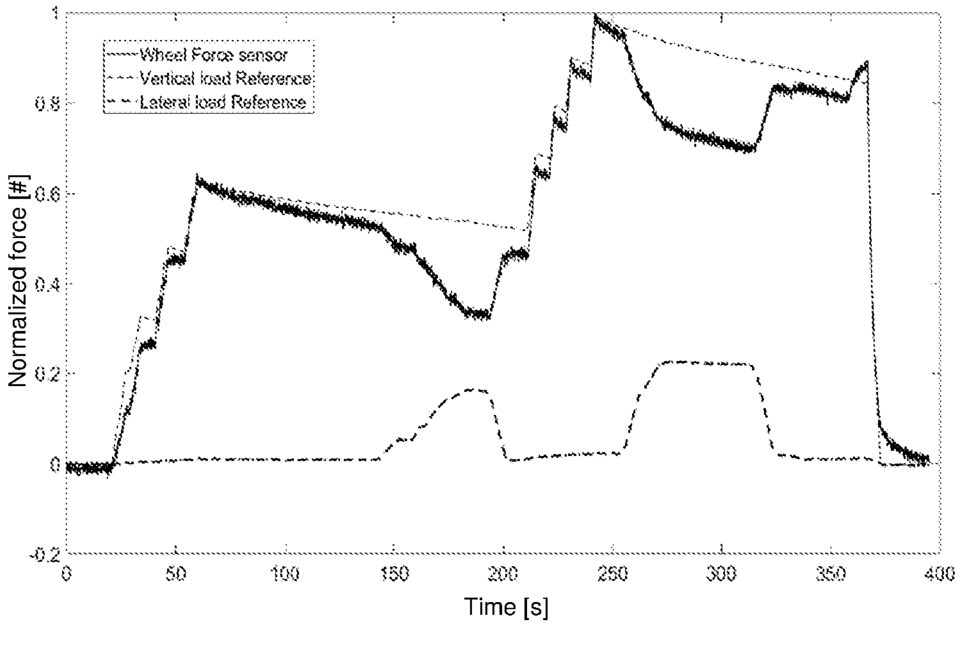
Wheel Force sensor
Vertical load Reference
Lateral load Reference
Normalized force [#]
Time [s]
-0.2
0
0.2
0.4
0.6
0.8
1
50
100
150
200
250
300
350
400

Fig. 8

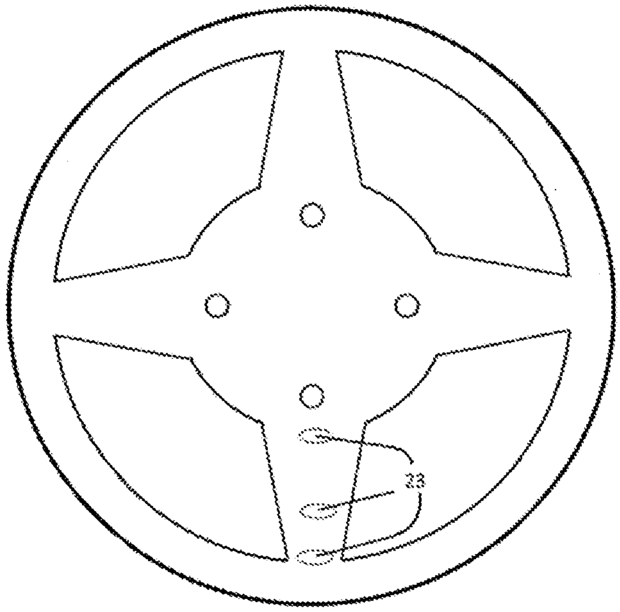

Fig. 9

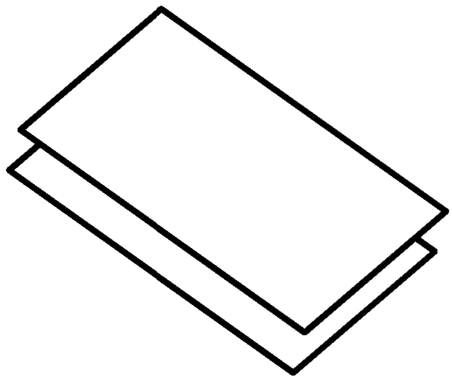

FIG. 10A

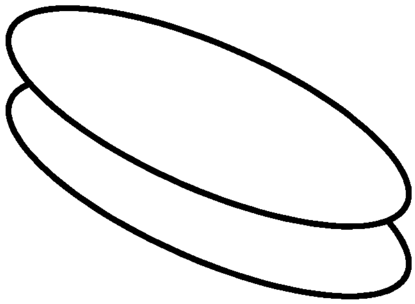

FIG. 10B

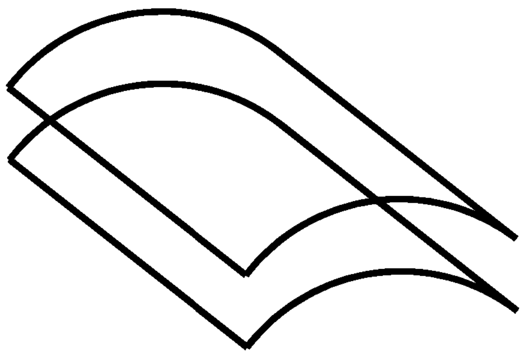

FIG. 10C

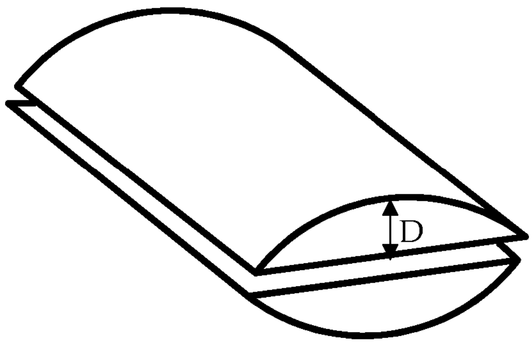

FIG. 10D

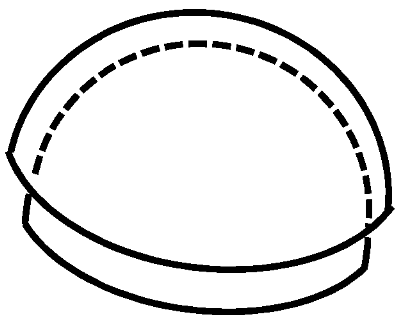

FIG. 10E

REFERENCES CITED IN THE DESCRIPTION

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